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Description and identification of transient structures in EEG

PhD thesis

Abstract

Keywords:
EEG – electroencephalogram – the recording of electrical activity of the brain
Polysomnogram – multi-channel recording during sleep, typically it is EEG with additional records of EKG, eye movements, muscle activity, chest wall movements, etc.
Artifact (in EEG) – transient structure in EEG resulted from electrical activity of sources other than the brain
ROC (ROC curve) – diagram of the sensitivity vs. specificity for a binary classifier system as its discrimination threshold is varied (ROC – receiver operating characteristic)

One fully extended overnight polysomnographic recording would be over half a kilometer long. Before any automatic analysis is applied, EEG has to be screened for the presence of artifacts by an experienced electroencephalographer. If we imagine how tedious a task it is, problems related to high cost and low repeatability become obvious.

The dissertation presents the prototype of an open, parametric system for automatic detection of EEG artifacts in polysomnographic recordings. It relies on independent parameters defined in time-frequency domain according to multidimensional signal analysis. Based on these parameters the system rejects the relative presence of each of the eight types of artifacts in a given epoch. An artifact is marked if any values of defined parameters exceeds a threshold. These thresholds, set for each parameter separately, can be adjusted manually by user or via "learning by example" procedure alike. "Learning by example" procedure is mathematically equivalent to multidimensional minimization with computationally intensive cost function. The procedure can be used to automatically tune the parameters to new types of datasets, environments or requirements.

Performance of the system was evaluated on 103 overnight polysomnographic recordings and verified against experienced electroencephalographer decisions. In results the system revealed concordance with decisions of human experts about 92%, which is close to the inter-expert agreement. To make this statement well defined, I used the ROC methodology for evaluation of detection process.

The system is open source complained, so complete source code is available from http://eeg.pl. A user-friendly version with Java interface is available from http://svarog.pl.